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GRAIN SMUT AND THE USE OF HOT WATER TO PREVENT IT.*

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One of the most important discoveries in the line of preventing or controlling diseases of crops, which has so far been brought to light, is the hot water treatment for smut in small grain (i. e. oat smut and bunt, [the hard or stinking smut] of wheat). The country loses several million dollars annually from this source, the loss being upon an average nearly or quite 10 per cent. of the total oat crop, and a variable part of the wheat crop.

It is now known that this loss is entirely preventable at almost no cost, and with little trouble. The remedy has been tried in Kansas and Indiana for three years past, and to some extent in other parts of the country. It is now recommended by quite a number of experiment stations and by the Division of Vegetable Pathology at Washington. The remedy is very simple. It consists in placing the seed grain for a short time in rather hot water. No poisons or other chemicals are used. As grain is usually machine sown it is necessary to dry it after the immersion, which is the most troublesome part of the operation, although the trouble is quite insignificant in comparison with the benefit derived.

So simple a means to secure so large a return ought to come into general practice in a comparatively short time; and the writer believes this will be the case if unnecessary restrictions and precautions do not deter the farmer from a fair trial of the remedy. To bring it into general practice it should be shorn of all niceties of manipulation, which are only proper in the hands

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of trained men, and be so devised that the average man is not made to feel that he needs to employ a scientist in order to safely undertake the trial.

A few months ago the leading article in *Science* (Feb. 26) gave a brief account of the method as recommended by the U. S. Division of Vegetable Pathology. The method for oats, as given in the article, is to immerse the seed in "water at a temperature of 110° F., until all the grains are thoroughly wetted; then plunge them into a second vessel, with the water heated to 132½°, for fifteen minutes." The writer goes on to say that "the treatment for wheat is similar, but the water should be heated to a temperature of 143½°, and the seed immersed only five minutes." There is certainly a strong indication in the wording of these directions that unusual care is required to secure success.

In the bulletin of the Division of Vegetable Pathology (Farmers' Bulletin, No. 5) the first method given above is recommended for both wheat and oats, and the following, with other "important precautions," is appended: "*Maintain the proper temperature of the water (132½° F), in no case allowing it to rise higher than 135° or to fall below 130°; this will not be difficult to do if a reliable thermometer is used.*" There is much more given in the same precautionary tenor, certainly enough to impress even a dull person that something more than the usual methods of the farm are demanded. To most farmers the requirement of a thermometer sufficiently accurate to make it worth while to attempt reading it to half degrees would be almost an insuperable barrier, and to maintain the temperature of the water with the ordinary appliances of a farm for fifteen minutes within a limit of five degrees would be by no means easy.

Other writers have urged the same exacting method, the data for which in most cases were derived chiefly from investigations made at the Kansas experiment station. Upon referring to the records of the tests made in Kansas (Bulletins 8, 12, 15, 21 and 22) it is seen that the highest temperature tried was 143½° F. for five minutes, which did not apparently injure the grain. No attempt was made, so far as one can judge by the published account, to ascertain the limits of temperature and time for safe treatment.

Such tests, however, have been made by the Indiana experi-

ment station (Bulletins 32 and 35), and they show a wider range for safety than the above limitations would indicate. The trials were in series with intervals of five degrees in the temperature and five minutes in the time. For wheat the limit of complete safety for five minute treatment was 135° F. and for ten minute treatment 130° F.; and raising the temperature ten degrees for either length of time respectively still left nearly three-fourths of the seeds in condition to germinate. With oats the range is

GERMINATION OF WHEAT AFTER TREATMENT WITH HOT WATER.

No. of seeds used.	Temperature of water.	Time of immersion.	Per cent. germinated in 24 hours.	Total per cent. germinated.
600	Untreated.	9.8	94
600	130° F.	5 min.	14.5	90
600	130° F.	10 "	12.5	93
600	130° F.	15 "	11.	86
600	135° F.	5 "	12.4	91
600	135° F.	10 "	5.2	82
600	140° F.	5 "	6.7	73
600	140° F.	10 "	0.7	65
600	145° F.	5 "	1.	62
600	145° F.	10 "	0.	20
600	150° F.	5 "	0.	33

fully five degrees higher for the same time of treatment, doubtless due, at least in part, to the protection which the hulls give to the seed. The accompanying tables are founded upon a large

GERMINATION OF OATS AFTER TREATMENT WITH HOT WATER.

No. of seeds used.	Temperature of water.	Time of immersion.	Per cent. germ. in 24 hrs.	Total per cent. germinated.
1000	Untreated.	7.3	95
1000	130° F.	5 min.	23.4	93
1000	130° F.	10 "	13.4	93
1000	130° F.	15 "	13.6	92
1000	135° F.	5 "	17.3	93
1000	135° F.	10 "	7.3	94
1000	140° F.	5 "	6.3	94
1000	140° F.	10 "	1.8	86
1000	145° F.	5 "	6.5	89
1000	150° F.	3 "	5.9	89

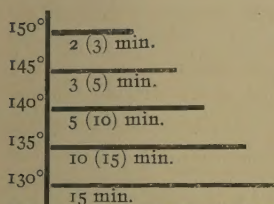
number of germinations, and although not strictly comparable on account of some variability of temperature during the time of

germination, yet are ample to serve as the basis of a formula for safe practical treatment.

Two factors are to be borne in mind in determining the range of treatment: the necessity of killing the spores of smut, which fixes the lower limit, and the necessity of preserving the grain uninjured, which fixes the upper limit. After determining the range, two reciprocal factors will enter into every treatment, time and temperature: the hotter the water, the shorter time required to secure the same results, and conversely, the longer the immersion the lower temperature required.

As to the lower limit at which the smut spores are killed there is a large amount of data, and a quite general agreement among investigators. The upper limit at which the germ of the grain remains uninjured I have just pointed out. It has been assumed that the medium between these extremes gives the proper data for practical work, and that the water should be maintained during the immersion of the seed at as near this medium degree of temperature as may be possible. Theoretically this is satisfactory enough, but it works badly in practice on account of the rapid lowering of temperature when the seed is first immersed, and the consequent difficulty of bringing the water back to the right degree of heat, and keeping it there. To overcome this difficulty as much as possible it is usually recommended to employ a preliminary bath of 110° to 120° , in which the seed is plunged until thoroughly wet and uniformly warm, from which it is transferred to the final treatment.

But why all this precaution and trouble? Why need the water be kept at a constant temperature during immersion? And why need a medium degree of temperature be selected, rather than any other within the range of effective treatment? Obviously these restrictions are the outgrowth and remains of the experimental period of the process, and need no longer hamper its application on the farm. The water which is to receive the grain may be heated to about the upper limits of safety, say 145° or 150° ; the seed in a suitable bag or other receptacle is then plunged in the water and moved about to permit it to heat uniformly. The length of immersion will be according to the rate at which the temperature drops, and is not to exceed the limits of safety for any degree at which the water is standing at the time. This



Horizontal lines indicate length of time in minutes for safe immersion of grain (figures in parentheses apply to oats, the others to wheat) at the several temperatures named.

is made plain by a simple diagram. If wheat be treated, and the water stands at 150° at the start, it can only be kept in the bath two minutes with safety, if the temperature remains constant. But if before the two minutes have expired the temperature drops to 145°, the time may be extended to three minutes, and so on.

In practice it is found that by using a barrel or large tub for the water, and treating a half bushel or so of grain at a time, it is safe to recommend to inexperienced farmers to heat the water to 145° at the start for both wheat and oats, and to immerse the seed with constant stirring for five to eight minutes, not allowing the temperature to drop below 130°. No preliminary bath is required, and any ordinary thermometer may be used. This method greatly simplifies the process, removes all technicalities, makes the operation more rapid, and is entirely effective in securing the results desired.

